LIMNOLOGY

Project title: Limnology Laboratory Fieldtrip: Impacts of Geothermal Inputs on a Stream Ecosystem: the Firehole River

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Objective: The objective of our field trip was to expose students to basic stream sampling approaches and examine how geothermal inputs structure river ecosystems. Students write a long report in the form of a scientific paper. I hope to continue this project for the foreseeable future, as it will contribute a small amount of stream monitoring each year for two sections of the Firehole River.

Findings: We used two study sites for the research, the Firehole River above the upper Geyser Basin, and the Firehole River upstream of Ojo Caliente, where it is hottest. We measure invertebrate abundance, algal biomass, discharge, geomorphology, temperature, alkalinity, pH, and ammonium concentrations. Alkalinity, pH, temperature, and algal biomass are higher at the hot site than the cold site. Invertebrate taxa richness is lower at the hot site, and we find exotic New Zealand mud snails there.

Project title: The Biogeochemistry of Sublacustrine Geothermal Vents in Yellowstone Lake, WY

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Objective: The overall objective is to develop a quantitative understanding of the biogeochemical impacts of hydro-geothermal activity in Yellowstone Lake. This includes 1) exploration and discovery of the distribution and geochemistry of hydrothermal vents within the lake using submarine technology in the form of remotely operated vehicles (ROV's) and in situ instrumentation; 2) quantification of biogeochemical fluxes and budgets; and 3) determination of the influence such fluxes have upon the biology of the system and the relative importance of photosynthetic, heterotrophic and chemolithotrophic production.

Findings: Mineral inputs to Yellowstone Lake, WY come from a variety of sources, including hydrothermal vents, ground water, rainwater, flux from sediments and direct runoff. One third of Yellowstone Lake is directly influenced by hydrothermal activity (hot water vents and fumaroles). Geothermally heated water percolating through the chamber is highly enriched in carbonate, silicate, chloride, and methane, with some locations additionally rich in iron and sulfide.

Microorganisms that live in high temperature ecosystems are tightly coupled to their environment. A detailed understanding of the geochemistry of hydrothermal environments can be an important component in deciphering critical characteristics for the presence of microbial life under these changing conditions.

More than 25 chemosynthesis incubations included more than 20 vent samples and an array of associated water column samples. Due to weather and scheduling constraints, the West Thumb and Mary Bay areas of the lake were intensely sampled while Stevenson Island and outlying areas near Mary Bay were postponed until 2002. This permitted us to apply more detailed analyses of chemosynthesis in the two regions than had been possible in previous years. Especially improved in 2001 (but not yet optimized) was examination of high temperature chemosynthesis (50–700°C) in parallel with in situ temperature incubations.

Vent waters in West Thumb typically contained sub-micromolar concentrations of Fe while those in Mary Bay and off Stevenson Island contain up to 10M. The water column concentrations of dissolved Fe range from 250 to 450 nM in Mary Bay, but were below detection (180 nM) in the waters of South East Arm, West Thumb, and off Stevenson Island.

Pore water and vent water chemistry provide evidence for lake water dilution of vents below the sediment-water interface. Significant fracturing of source water conduits was indicated by extreme differences in pore water profiles from cores less than 5 m apart in geothermally vigorous West Thumb. Some samples approached theoretical reservoir composition for conservative geochemical tracers.

Porewater results from the geothermally active areas of Mary Bay and West Thumb show Cl- enrichments reaching several mmolar and, in the case of Mary Bay, extrapolate to the geothermal end member (~ 20 mM) at a Departmenth of only 2–3 m. These steep concentration gradients support diffusive Cl- fluxes across the sediment-water interface three orders of magnitude higher than those in non-venting depositional areas.

Project title: Biocomplexity-Incubation Activity: Developing Conceptual and Mathematical Approaches to Model Transport and Transformation of Elements Through a Geothermal Landscape

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Objective: The objective is to develop a research proposal and program under the National Science Foundation Biocomplexity initiative. As part of this proposal we are mining previously collected data, and collecting preliminary data, and holding workshops and meetings in Yellowstone. Our research will address interaction of hydrology, geochemistry and microbial uptake on controlling element transport and transformation in geothermal streams in the Firehole basin.

Findings: In 2001 we held a workshop in Yellowstone and collected some water chemistry data from previous Yellowstone research. We collected very preliminary data on element concentration along geothermal tributaries to White Creek and Rabbit Creek. Both streams show strong changes in pH and water chemistry that correspond to physical processes such as degassing of CO_2 and uptake of nitrogen by microbes.